was required for the Pi-ho river, which intersects the line. The apparatus used are Morse's die-writers worked by Leclanché elements. Mr. Betts and some of his assistant pupils have been invited to visit Formosa in order to construct a line on the west coast of this island, viz., between Kee Lung and Tay-wan-foo. It is also proposed to establish another line at Tian Tsin, connecting that city with the capital of the province Paou-ting-foo.

DURING the year 1877 the Parisian press numbered no less than 836 different newspapers and serials (against 754 in 1875). Of these, 51 daily and 14 weekly papers are political, 49 serials are theological (37 Catholic, 10 Protestant, and 2 Israelitic); 66 are dedicated to law, 85 to political economy, 20 to geography, 74 to *belles lettres*; 20 are pedagogic, 52 literary-scientific, 56 artistic, 68 treat of fashions, 77 of technology, 75 of medicine; the contents of 43 are mathematical and natural-scientific, of 22 military, of 31 agricultural. Besides the above there are 16 sporting papers, 13 of various contents, and 4 dedicated to Freemasonry.

MANY alloys of tin and other soft metals hardened by addition of antimony, copper, &c., do not give a clear tone on being struck, but a lead-like, dull one. It has been found by M. Lilliman (*Pol. Notizblatt*) that the power of sounding clearly may be imparted to them, by immersing them for a half to one minute in a paraffin or oil bath, heated to a temperature 5° to 5°·5 below the boiling-point, then taking out and allowing to cool. This does not produce any diminution of density, but a considerable increase of the hardness and rigidity.

THE *Proceedings* of the Bristol Naturalists' Society (vol. ii. part 1, new series) contains, as usual, some papers of more than average value. There are three papers on the microscope by Dr. Fripp, two on the Bristol coalfield by Mr. W. W. Stoddart, besides two other geological papers by the same author, a paper by Mr. W. Evans on the scientific aspects of tanning, and other matters of importance. The *Transactions* of the Bedfordshire Natural History Society for 1876-7 contains a number of good papers on local natural history.

THE gasworks at the Grasbrook at Hamburg have recently been covered with a gigantic iron roof, constructed by the "Essener Union." Its weight is 51,500 kilogrammes, its length 84 metres. With the exception of the roof on the Liverpool gasworks, it is the largest in Europe.

AT the meeting of the Royal Academy of Sciences at Berlin, on January 24, Prof. Du Bois Reymond, as President of the Committee of the Humboldt Institution for Naturalists and Travellers, read a detailed report of the activity of this institution during the past year. The first undertaking was that of Herr J. M. Hildebrandt, and referred to the exploration of the snow-clad mountains of Equatorial Africa, viz., of the Mt. Kenia and of the Kilima-Ndjaro. The well-known traveller, although he approached the former mountain to within a few days' march, could not reach it altogether on account of the unconquerable difficulties placed in his way by the enmity of the native tribes, but he will again take up his plan after having recruited his health at home. Herr Hildebrandt, however, has brought home rich scientific collections from his journey, and has presented them to the scientific societies at Berlin; his geological collections are of special interest. The second traveller sent out by the Humboldt Institution, Dr. Karl Sachs, continued and terminated his investigations on the electric eels (*Gymnotus electricus*) at Calabozo, an important town in the Llanos of Venezuela. He succeeded in adding to our knowledge of *Gymnotus* considerably, so that of this species now quite as much is known as of *Torpedo*; he failed, however, to throw any light upon the development of *Gymnotus*. Dr. Sachs is now occupied in writing a treatise on this subject, as well as a description of the country and the people of Venezuela and his own experiences while travelling.

IT is very unsatisfactory to hear that the consignment of soles and turbot which left the Southport Aquarium on January 3 for the purpose of stocking the Bay of Massachussetts has turned out almost a total failure, one pair of the former only having arrived at their destination in safety. 'Prof. Baird, United States Commissioner of Fish and Fisheries, is so anxious to introduce the above-named fishes into American waters that another journey to England is contemplated about May next. Much experience has been gained in the transit of live fish across the Atlantic, which will be of considerable importance in facilitating future arrangements. It is highly probable that the bony pike and other American fishes, many of which are remarkable for their brilliancy of colour, will ere long find a home in English aquaria.

THE additions to the Zoological Society's Gardens during the past week include a Common Swan (*Cygnus olor*) from Holland, presented by Mr. John Colam, F.Z.S.; two Crested Guinea Fowls (*Numida cristata*) from West Africa, presented by Mr. Collingwood; two Canadian Geese (*Bernicla canadensis*) from North America, presented by Mr. Edward J. Philpot; four Reeves's Terrapins (*Clemmys reevesi*) from China, presented by Mr. A. Thomson; a Brazilian Tortoise (*Testudo tabulata*) from Cartagena, presented by Capt. King; a Poitou Donkey (*Asinus vulgaris*) from the south of France, deposited; an Azara's Fox (*Canis azaræ*) from South America, purchased.

D'ARREST'S SPECTROSCOPICAL RESEARCHES

WHEN the late Prof. d'Arrest was called to superintend the building of the new observatory in Copenhagen and the erection of a large refractor (16 feet focal length by 11 inches aperture), he took advantage of the opportunity thus offered to enter into more extensive researches on the nebulæ, than he had been able to undertake at Leipzig. He intended at first to observe all the nebulæ which were visible in his refractor, but he soon found that a work beyond human power, and that in fact the nebulæ are infinite in number. Working hard for six years he was only able to collect the eighth part of the observations required for laying down approximate positions of all those nebulæ which are distinctly visible in the Copenhagen refractor, and whose places could be exactly determined. These observations were published as "Siderum nebulosorum observationes Havnienses," in 1867, for which the gold medal of the Royal Astronomical Society was awarded to him in 1875. Prof. d'Arrest died eight years after the publication of his great work, his health broken down by constant night-watches. These years were spent mostly on spectroscopical researches, which were partly published in the *Astronomische Nachrichten*, partly in a separate paper, "Undersögelser over de nebulose Stjerner i Henseende til deres spectralanalytiske Egenskaber," in 1872. This latter paper does not appear to be so widely known as it deserves, and an abstract in the columns of NATURE might therefore be acceptable to many.

It took D'Arrest several years to get sufficiently acquainted with the use of the new apparatus—so different from those usually handled by astronomers of the old school. Various forms of spectroscopes are employed according to the subject to be examined. To observe the protuberances or their lines the greatest possible dispersion is required in order to weaken on one hand the sun's light, and on the other hand the diffuse atmospherical light which forms the background on which the lines are projected; while prisms of small dispersive power are employed when for instance the bright lines of comets or nebulæ are examined. D'Arrest's spectroscope was not intended for any extreme application; it was a so-called Janssen's, after Amici's principle composed *à vision directe* of three crown and two flint-glass prisms from Merz.

The solar light has lately been made to go twice through the system of prisms, and the dispersive power thus doubled has rendered many more bright lines visible than were known

heretofore. Besides the principal lines C, D_3, and F, discovered in 1868, only three or four feeble secondary lines of unusual occurrence were known in the spectrum of the sun's chromosphere, until Prof. Young, in the autumn of 1871, succeeded in raising the number of the visible bright lines to 103 in the course of only four weeks by the above method. These lines are almost uniformly distributed over the whole spectrum from wave-length 706 to 410. The lines are, however, of very varying brightness and frequency. But that artifice is of no good for investigating the planets or planetary nebulæ, for which instruments of the greatest possible amount of light are required.

D'Arrest did not make any profound study of the SUN'S protuberances, but convinced himself of most of the many peculiarities that have been discovered since autumn 1868. He mentions especially the pointed extremities of C and D_3, and the broad basis and *fine point* of F. This is explained by a lowering of temperature and density at a distance from the sun's surface, but it is certain that this phenomenon, with its physical consequences, appears with very different intensity by C and by F, from what it does by Hα and Hβ of hydrogen. It appears remarkably enough most distinctly by the feeblest of the two. The lines Hγ and Hδ are in themselves far more insignificant, and their extension no doubt smaller. D_3 is of another unknown origin. He often observed, besides, the oblique position and distortion of the F-line in protuberances, which were evidently produced by violent eruptions, but he never saw distortions so violent that the line shoots branches to both sides, and at last is altogether dilacerated. Lockyer has represented many such cases in vol. xviii. of the *Proceedings* of the Royal Society. Secchi does not mention them in his book on the sun (Paris, 1871), and they have perhaps only been seen by Young besides. As to the explanation, we meet with a difficulty similar to that above; the phenomenon shows itself principally and nearly exclusively in this single line. D'Arrest never noticed such a thing in Hα. It is explained by the rapidly rotating mass of hydrogen towards or from the slit of the spectroscope, the wave-length of the light being thus alternately lessened and increased. He calculated a velocity of fifty or sixty geographical miles in the second from the greatest displacement he noticed by the F-line. The direct consideration of the occasional explosive alterations of protuberances leads to similar conclusions. It is beyond doubt that the velocity is so enormous. Much smaller displacements could besides hardly be ascertained by means of the spectroscope.

The spectra of the *sun-spots* have been examined ably by different investigators, and a rich material exists which shows the most probable assumption to be that the sun-spots are the results of cooling. It is in fair accordance with this interpretation that the increased absorption of light which the spot-spectrum shows by augmentation of the lines in breadth and darkness is considered a proof of the condensation of the gases, to whose absorption the dark lines in the normal sun-spectrum owe their origin. According to d'Arrest's opinion, this pervading *élargissement* must be mainly attributed to the circumstance that the lines are seen on a darker background where the irradiation is greatly lessened, and he believes that the whole theory, which is founded on the supposition of elective absorption of the spots is not quite to be trusted as yet. He never saw bright lines in any spot-spectrum, and mentions that other assiduous observers have likewise failed in this respect. The normal dark lines in the sun-spectrum are of very different degrees of darkness and breadth; some exhibit sharp borders, while others are winged, &c. These intrinsic relations he remarked did not change in the spot-spectra from what they were in the neighbouring region. He found, for instance D_2 to enlarge more than D_1 in proportion to their different breadths in the normal spectrum. From the lessened irradiation, moreover, some sharp lines of the normal-spectrum may become somewhat foggy in the spot-spectrum, as Secchi (*Compt. Rend.* 1869, p. 520) states is the case with the principal lines of sodium, a circumstance which, however, d'Arrest did not confirm any more than the remark by the same astronomer that the lines of magnesium are hardly enlarged in the spot-spectrum. Lockyer says (*Proceedings*, Royal Society, vol. xvii. p. 352) that they are thicker when observed in a spot than usual. Vogel has remarked a similar thickening of easily visible dark lines in Jupiter's spectrum in those parts of the spectrum which correspond to the dark bands on the planetary disk.

D'Arrest does not consider his observations as sufficient to establish anything as to the encroachment of the gas lines in the spot-spectra which occasionally has been observed by the so-called light-bridges in the interior of the spots; he remarks that a similar phenomenon may be produced spontaneously by looking at the image of one of the gas-lines of the protuberances, when the slit is not placed exactly in accordance to the refrangibility of this particular line, and investigators may not have been sufficiently attentive to this circumstance. The light concentrated in the few protuberance-lines is of course stronger than the light of the continuous spectrum of the border, and when the slit is even very slightly displaced the protuberances appear distinctly to reach within it. The same is the case with protuberances inside on the disc of the sun, where they mainly betray themselves by partial reversal of some lines from dark to bright.

The whole of astronomical spectrum analysis is founded upon the law that the source of the light of a continuous (with or without dark lines) spectrum containing rays of every refrangibility, is a solid or fluid substance, and that the source is a glowing gas whenever the spectrum is discontinuous and reduced to separate bright lines. This must within certain limits of pressure be considered as raised beyond doubt, although most skilful chemists disagree as to the nature of spectra of different orders. Plücker and Wüllner state that the same substance gives different spectra at different pressures and temperatures. Dubrunfaut, Reitlinger, and, above all, Angström deny this. The special use which has been made of Geissler's tubes in astronomical observatories is at any rate rather doubtful, since chemists have shown the true nature of the compound spectra which such tubes may furnish—for instance of hydrogen and nitrogen.

Dr. Huggins examined for the first time on August 29, 1864, one of the brightest planetary nebulæ (H., iv. 37) and found the spectrum concentrated in three short bright lines. This discovery proved the nebula to consist of glowing gas under a feeble pressure. Thus also for the first time was obtained the means of distinguishing between true nebulæ and conglomerations of stars. The latter, by far the most common, show the continuous spectrum, the former the linear. This question would hardly ever have been definitely answered by aid of any telescope. First Huggins, then Rosse and Secchi examined almost all those nebulæ in the northern sky, which were visible in their apparatus, and only one or two observers have since made further investigations on the single objects. Capt. J. Herschel examined (1868) in India the southern nebulæ spectroscopically. Most gaseous nebulæ are planetary. D'Arrest had already in his smaller catalogue in 1855 remarked about H. iv. 18: "bluish quiet light, as all planetary nebulæ seen by me show it," and in 1866 in "Obs. Havn." about H. iv. 37:—"Unica prope inter nebulas et prorsus singularis. Ellipsis est egregie cærulea cet." We now know both these to be gaseous nebulæ, analysis showing the light concentrated into three lines near each other in the green and blue regions of the spectrum.

The exact determination of the place of the lines in the normal spectrum was connected with great difficulties on account of their feeble light. It was therefore at first uncertain whether the three lines were identical in the different spectra, but there can now be no doubt as to this, and d'Arrest found by a discussion of the observations of Capt. Herschel, Secchi, and especially Vogel the following wave-lengths for the lines. The line Neb. (3) has by Huggins and Miller, Secchi, and lately Vogel, been proved to coincide with the F-line (Hβ) and d'Arrest assumes in consequence its wave-length after Angström:—

	Wave-length.	Vibrations in 1 second.
Neb. (1) ...	500·40 mill. millim. ...	596·64 billions.
Neb. (2) ...	495·66 ,, ,, ...	602·35 ,,
Neb. (3) ...	486·06 ,, ,, ...	614·25 ,,

Beyond Neb. (3) is occasionally (by H. iv. 18 and the Orion nebula) perceived a fourth line Hγ, but it is very difficult to see it.

The spectra of the different objects are, however, very unlike each other on account of the different *intensity* of the bright lines. There is even occasion to presume that the *mixed gas spectra* do not ever continue unchanged with regard to the relative intensity of the lines, which is very likely, as the relative brilliancy of both the green lines of glowing H and N depends upon the mixture of the gases.

We know that air when under a feeble pressure heated by an induction-current, exhibits the line Neb. (1); it belongs to *nitrogen*.[1] Lockyer and Frankland (*Proceedings*, Royal Society, vol. xvii. p. 454) have shown that the in reality very complicated spectrum of nitrogen, under certain circumstances of pressure and temperature, is reduced to this bright line with but feeble traces of the

[1] D'Arrest mentions that the above wave-length agrees perfectly with Huggins's observation, when he identifies Neb. (1), not with the middle of the double line, but with the least refrangible of the two.

others. It is, besides, the brightest of them all. Extensive investigations published on this subject cannot, however, be said fully to elucidate the question why the other lines of nitrogen do not appear in the spectrum, nor do physicists agree as to the temperature and density which, under these circumstances, must be supposed in the nebulæ. It is, besides, precarious to draw from phenomena observed in Geissler's tubes conclusions as to circumstances prevailing in the vast nebulæ (Zöllner, *Berichte der k. sachsischen Gesellschaft d. Wissensch*, for 1870, p. 254). It appears less important that nobody has been able to comply with Angström's demand when he says ("Recherches sur le Spectre solaire," p. 37) :—"This line is double. . . . It appears, therefore, that we ought to be able to show this duplicity in the corresponding line of the nebular spectrum." To their separation is required too narrow a slit for the feeble light of the nebulæ. All considered, nitrogen is at present very likely one of the constituents of nebulæ.

The origin of *Neb.* (2) is not known. The idea at first occurred to Huggins of one of the many barium-lines, but he soon gave this idea up. One of the iron lines holds exactly its place ; it is a dark line, but not one of the principal of the rich spectrum ; of course this coincidence is accidental. This line is again met with in the spectrum of many red and variable stars. The measures of Vogel (*Ber. d. k. sachs. Gesellsch. d. Wissensch.*, 1871, December 17) agree well enough with the gaseous line when the great difficulties of the cases are taken into account. *Neb.* (2) does *not* occur in the spectra of comets.

Neb. (3) is identical with the line Hβ of hydrogen, whose existence in gaseous nebulæ was proved when Huggins discovered Neb. (4), which is Hγ, that was so long sought for in vain. Hydrogen is everywhere found as one of the constituents of the heavenly bodies, but the comets contain no traces of it. The hydrogen-lines appear even in the spectra of many fixed stars, at least through Hα and Hβ, but sometimes Hβ and Hγ are the strongest (β Lyræ), and three hydrogen lines are distinctly seen in the spectra of α Aquilæ and α Lyræ.

D'Arrest then gives in his paper a list of all the nebulæ which have been spectroscopically examined by himself or others.

He speaks first of the gaseous nebulæ, of which H. iv. 37 is the most remarkable ; then he mentions those whose spectra are continuous, and thus proved to be mere conglomerates of stars. The latter are by far the most difficult to examine, the feeble light being distributed over a large space, and generally minima visibilia. An astronomer well versed in the use of the spectroscope is, however, often able to decide whether the spectrum is continuous, even if it be not visible by glimpses. Already the absence of the spectrum may occasionally hint about the true nature of the body. He estimates the number of nebulæ known in the middle of 1872 to be about 6,000 ; of these 150 have been examined with the spectroscope. It is, therefore, only the fortieth part, which is bright enough to be seen through the system of prisms. Although it is hardly possible to draw conclusions from so small a fraction of the whole, still d'Arrest thinks it possible, on account of the critical revision he has given the observations, to arrive by induction at a few results. He finds that of a given number of nebulæ about a fourth give the discontinuous spectrum, while three-fourths give the continuous.

Gas nebulæ are, with but few exceptions, known by their green-blue light, their sharply-defined, round, or elliptic discs with annular bright condensations inside. There are, however, large, extensive, irregular, and complicated nebulæ, which also consist of the three gases, nitrogen ever foremost, though the gases are mixed in different proportions. The very feeble continuous spectrum which appears in many planetary nebulæ can in most cases be shown to arise from the consolidated nucleus, the fluid or solid central mass. The distribution of brightness in extensive nebulosities is very irregular, and the heat in certain regions rises and falls occasionally a little, though no real alterations in the form are known as yet.

The ray-nebulæ are surely mere conglomerations of stars. Those are the long, lenticular nebulæ, often so narrow and fine that such an object may resemble a thin bright line drawn through the nucleus. No such nebula is hitherto known to give a tri-chromatic spectrum.

It was in 1866 that Secchi commenced to examine red stars with remarkable broad bands in the spectra, and he was already, in 1868, compelled to add a fourth class to his three classes of star-spectra. A systematical search after remarkable star-spectra was undertaken in 1873 and following years in Copenhagen. D'Arrest's four papers in *Astronomische Nachrichten* contain only the most remarkable of those he found, and only such as had not previously been mentioned. That most are above the eighth magnitude is evidently only founded on the difficulty of seeing spectra of smaller stars.

The circumstance which Secchi remarked in 1868, that yellow and red colours are so often connected with prominent spectra, seems certainly to be of importance, but the many exceptions should warn us from here expecting any great cosmical law. Neither is their connection with variability a rule without exceptions. There are many strongly coloured stars with very indifferent spectra.

Most of the spectra described are of the third class. These are not uncommon, for when we examine 140 stars we may expect to find one of the third class. They are uniformly distributed over the sky, and found also by white stars. The character of spectra of this class is constant throughout. The positions of the dark bands were also shown by Vogel, in 1872, to be the same for four bright stars. The columns are generally more distinctly separated towards the red end of the spectrum, though the contrary occurs also, and it is even possible to follow the steps from but finely-indicated bands to absolute discontinuity, but the colour has nothing to do with these gradations.

Still more intimately connected with orange colour is the fourth class, and specimens of this class are, in consequence, very uncommon. D'Arrest ascertained that the dark bands in the star-spectra are formed by groups of compressed dark lines against Secchi's experience. He examined spectra of stars with great proper motion, and found, for instance, the spectra of 61 Cygni and 1830 Groomb. to be indifferent, uniform, and continuous. General similarity of the spectra in certain parts of the sky does not exist at all, or has not been proved yet ; for instance, it is not true that red and yellow are wanting in the spectra of small stars in Orion. W. D.

THE PROGRESS OF METEOROLOGY[1]

AT the opening of his address Dr. Neumayer regretted that the general knowledge and public appreciation of meteorology was still very small in comparison with that of other branches of science. The main object of his address was therefore to induce his hearers to do all in their power to effect a more perfect and detailed understanding of this branch of science among their countrymen in their respective spheres of activity. He treated the subject, and particularly the weather-forecasts, mainly from his own point of view as a naval officer, and pointed out how desirable a greater interest in marine affairs would be in all circles of German home life. The course which meteorology in its application to daily life has taken may be divided into two categories of observations, first the uninterrupted systematic meteorological investigations, and second, the atmospheric disturbances or phenomena governed by the laws of winds, as first described some fifty years ago by Prof. Dove. He then gave a sketch of the progress of meteorology in other countries ; of the establishment of the numerous meteorological stations, and the application of telegraphy to this science ; of the enormous help afforded by the introduction of rapid means of communication. He pointed out how the greatest progress was made by the United States of North America ; that England was second in this respect, and was followed by Holland, France, and Denmark. According to the latest news, the yearly budget for meteorological observations in the United States was raised from 250,000 to 450,000 dollars, apart from all personal expenses. The rise in this sum is explained by the necessity of having special telegraph wires and stations solely for the meteorological service and by the increase in the staff of observers. If in Europe the practical results of observations are not quite as satisfactory as might be desired, it is because the European organisation of the meteorological service is far more imperfect than the American one. The German Government has given its full attention to this important science, particularly with regard to the German navy and the coast population. The poor German fishermen in the Baltic and the German Ocean are already deriving great benefit from the numerous meteorological stations which have been established along the German coast-line, although it is only eighteen months since the service has begun. The German "Seewarte" has been established and now performs its share of international work along with the sister-establishments of England, Holland, and France. Agriculturists will

[1] Meteorology in Daily Life. Address delivered at the meeting of the German Association at Munich, by Dr. G. Neumayer, Director of the Deutsche Seewarte at Hamburg.